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OBSERVATIONS OF TWO UNUSUAL ECLIPSING BINARIES, FN CAM AND AG VIR

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Abstract. Based on the results of classification of eclipsing binaries, we have compiled a list of stars that are promising objects for future study. We have started an observational campaign with telescopes of the Kourovka Observatory, Russia and present the first results of this work.

Key words: stars: binaries: eclipsing – stars: individual – techniques: photometric

1. INTRODUCTION

Binary stars provide methods permitting independent estimates of such fundamental stellar parameters as mass, radius, luminosity, etc., provided that we observe a binary star simultaneously as an eclipsing variable and as a spectroscopic binary with lines of both components visible in its composite spectra (SB2). The precision of derived values will be as good as several percent. However, such systems constitute only about 2% of the full number of known binaries, and this fraction is not expected to increase considerably in future.

On the other hand, there are a huge number of eclipsing binaries discovered in ground-based and space surveys that still remain unstudied. We can use the limited amount of available information on new binaries for determinations of their evolutionary stage and to search for unusual systems belonging to rare evolution stages. For these purposes, we developed a method for assessment of the evolutionary status of eclipsing binaries using light-curve parameters and spectral classification (Avvakumova & Malkov 2014). We have applied the procedure to the list of eclipsing binaries, which were collected in the catalogue of eclipsing variables (CEV[1], Avvakumova et al. 2013). About 4000 binaries were classified successfully, but we have also found that some systems cannot be classified at all or multi-valued classification is possible. To find out the reason, we have checked all these binaries with the literature and stated the following three problems:

• Obsolete or unconfirmed values of observational parameters can obstruct the classification.

• Contradictory values of parameters can lead to uncertain classification.

• Extreme and unusual systems sometimes cannot be classified.

The last item is the source of promising binaries with unusual evolutionary status that can be very useful for stellar evolution theories, while both the first and the second ones can be solved with new observations and/or studies.

Full lists of unclassified binaries were published with the CEV at the CDS. Based on data about binaries which satisfy the first and second items above, we have compiled a list of twelve objects that we can observe photometrically and spectroscopically with telescopes of the Kourovka Observatory. The list of binaries is presented in Table 1. Our observational campaign has started in January of 2014.

In this paper, we present preliminary results of our observations of two eclipsing binaries, FN Cam and AG Vir, for which we found contradictory data on their evolutionary state. In Section 2, we give a short description of known properties for both binaries. In the next section, we describe our observations and their reduction for each system. We draw our conclusions in Section 4.

2. PROPERTIES OF THE STUDIED SYSTEMS

2.1. FN Cam

FN Cam (α=09$^{\rm h}$22$^{\rm m}$58$\overset{\rm s}{.}$04, δ=+77°13′10.9″, 2000.0; $V_{\rm max} = 8^{\rm m}.64$) is an SB2 eclipsing binary discovered by Hipparcos (Perryman 1997). Rucinski et al.(2001) published the first radial velocities and classified the system as A-subclass of W UMa systems, in agreement with the results of the light curve solution (Pribulla et al. 2002b). Pribulla et al. (2002a) emphasized that the system was quite overmassive for its spectral classification.

Csizmadia & Klagyivik (2004) added FN Cam to their catalogue and, opposite to the conclusions of Rucinski et al.(2001), classified it as W-subclass of W UMa binaries. Selam (2004) derived a new solution of the light curves from Pribulla et al. (2002a) from Fourier fitting. His results differ slightly from those of Pribulla et al. (2002a).

Therefore, both A and W types are possible for FN Cam and the question is still open. This binary being an SB2, the masses and radii of its components can be determined to a good precision. We have decided to observe it spectroscopically with the high-resolution UFES spectrograph of the Kourovka Observatory. These observations give the opportunity to derive new radial velocities and estimate spectral types for both components. A simultaneous analysis of radial velocity curves and new photometric light curves will lead to the determination of physical parameters.

[1] Its online live version can be downloaded from http://www.inasan.ru/∼malkov/CEV/

Table 1. The list of program binaries.

Name	$V_{\rm max}$ mag	Coordinates (2000.0)	Time of observations	Technique
FN Cam	8.64	$09^{\rm h}22^{\rm m}58\overset{\rm s}{.}04$; $+77°13'10.9''$	Jan–March	CCD[a] (V, R); HRS[b]
AG Vir	8.78	$12^{\rm h}01^{\rm m}03\overset{\rm s}{.}50$; $+13°00'30.0''$	Feb–April	CCD (V, R); HRS
ϵ UMi	4.22	$16^{\rm h}45^{\rm m}58\overset{\rm s}{.}24$; $+82°02'14.1''$	May–June	HRS
TZ Dra	9.32	$18^{\rm h}22^{\rm m}11\overset{\rm s}{.}67$; $+47°34'08.0''$	May–June	CCD (V, R); HRS
V1034 Cyg	10.06	$20^{\rm h}05^{\rm m}34\overset{\rm s}{.}81$; $+30°58'33.1''$	June–Sept	CCD (V, R); HRS
V628 Cyg	12.20 (B)	$21^{\rm h}34^{\rm m}03\overset{\rm s}{.}96$; $+47°14'21.9''$	July–Sept	CCD (V, R)
V680 Cyg	10.35	$21^{\rm h}53^{\rm m}44\overset{\rm s}{.}44$; $+53°48'13.06''$	July–Sept	CCD (V, R); HRS
V741 Cas	8.14	$00^{\rm h}10^{\rm m}10\overset{\rm s}{.}46$; $+64°38'48.2''$	July–Sept	CCD (V, R); HRS
ZZ Cep	8.60	$22^{\rm h}45^{\rm m}02\overset{\rm s}{.}61$; $+68°07'58.4''$	Aug–Oct	HRS
GS Cep	10.41	$22^{\rm h}51^{\rm m}29\overset{\rm s}{.}51$; $+57°00'17.9''$	Aug–Oct	CCD (V, R);
RX Ari	9.41	$02^{\rm h}15^{\rm m}20\overset{\rm s}{.}78$; $+22°34'11.1''$	Sept–Nov	CCD (V, R); HRS
AL Cas	12.30 (B)	$02^{\rm h}13^{\rm m}44\overset{\rm s}{.}65$; $+70°08'42.9''$	Sept–Nov	CCD (V, R)

Notes: [a] ccd photometry; [b] high resolution spectroscopy

2.2. AG Vir

AG Vir (α=$12^{\rm h}01^{\rm m}03\overset{\rm s}{.}50$, δ=$+13°00'30.0''$, 2000.0; $V_{\rm max} = 8^{\rm m}.52$) is one of the eclipsing binaries with well-known and stable O'Connell effect. It was the subject of numerous investigations since its discovery by Guthnick & Prager (1929). The review of observations of AG Vir published till 1970 can be found in Blanco & Catalano (1970). Photometric studies of AG Vir were performed by Wood (1946), Binnendijk (1969), Blanco & Catalano (1970), Niarchos (1985), Kaluzny (1986). Blanco & Catalano (1970) analyzed all previously published minima times and supposed a cyclic variation of the orbital period together with its secular increase. They classified the system as a semidetached one, with the more massive primary filling its Roche lobe.

Kaluzny (1986) derived a solution of the published light curves with the Wilson-Devinney code. According to his suggestions, the system is a contact one, with components in a poor thermal contact, and the light curve asymmetry can be explained with a "hot spot" on the surface of the more massive and larger primary.

Bell et al. (1990) showed that the orbital period was stable and that the physical configuration of AG Vir depended on the adopted spot model. However, Qian (2001) demonstrated that the O–C residuals could be interpreted as the sum of a secular period increase and cyclic variations, with a period close to that from Blanco & Catalano (1970). The cyclic variations are caused by the third body, a trace of which was later found by Pribulla et al.(2006). Pribulla et al. (2011) carried out photometric and spectroscopic observation, but failed to derive a simultaneous solution of light curves and broadening functions (BFs). They noticed that BFs of AG Vir indicates a stream of matter or a bright region.

Despite many investigations, there are no clear conclusions about the evolutionary status of AG Vir and properties of its components. The possible configuration of the 'hot area' is also still unknown. Pribulla et al. (2011) stressed that high-resolution spectroscopy near the H_α or Ca II H and K lines was needed for future studies. Because of these reasons, we added this binary to our list.

3. OBSERVATIONS AND REDUCTIONS

Photometric observations of FN Cam and AG Vir were carried out between February and April, 2014 with the Master-II-Ural telescope at Kourovka Observatory (Lipunov et al. 2010). During 7 nights, we obtained 2793 frames in the V and R bands with 5 s and 10 s exposure times for FN Cam. Because of non-optimal weather conditions, we obtained only about 1000 frames in the V and R bands for AG Vir.

For photometric calibration, we used dark-current frames obtained before each observational night and flat-field frames obtained on the morning twilight sky after every observational night. All observations were carried out in automatic mode.

The complete reduction process was performed for 2414 frames of FN Cam and for 974 frames of AG Vir, both in the V and R bands. The mean accuracy of our measurements is 0.002 mag in both filters for each of the binaries.

To convert the instrumental magnitudes to the standard system, we have used photometric data of the APASS (The AAVSO Photometric All-Sky Survey) project for the same sky region, for all non-variable stars fainter than 10 mag.

Using the Kwee and van Woerden (1956) method, we have calculated four minima times that are listed in Table 2. We also checked the O–C curves of both binaries for possible variability but did not get any clear evidence of any kind of variations.

Table 2. Minima times for FN Cam and AG Vir.

FN Cam			AG Vir		
2456710.34622 (11)	II	V, R	2456769.40757 (42)	I	V, R
2456711.36155 (15)	I	V, R	2456770.37683 (41)	II	V, R

4. CONCLUSIONS

In this paper, we have presented preliminary results of our observations of two eclipsing binaries, FN Cam and AG Vir. We observed both stars photometrically in the V and R bands and achieved an almost full phase coverage for FN Cam, while for AG Vir our observations cover only a part of the phased light curve.

The follow-up of our work includes analysis of spectroscopic observations that were carried out for both stars as well as estimation of physical parameters for these binaries based on our photometry and spectroscopy.

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